RESEARCH DEPARTMENT

MEASUREMENT OF NOISE FACTOR, OSCILLATOR STABILITY AND FREQUENCY RESPONSE OF FIVE COMMERCIAL TELEVISION RECEIVERS

Report No. G-059

(1955/20)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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SUMMARY

This report describes measurements made on five commercial television receivers manufactured between 1951 and 1954. The measurements, which include noise factor, drift of oscillator frequency, r.f. and i.f. passband shape, modulation-frequency response and group delay, are recorded here as representative characteristics for receivers made in this period.

1. INTRODUCTION.

In order to provide information on the performance of commercial television receivers, measurements were made on five models of different manufacture which were considered representative of present-day design. The tests included:

a. noise factor

b. frequency drift of the local oscillator with time, after being switched on from cold

c. frequency response of the r.f. and i.f. amplifiers

d. modulation-frequency response

e. modulation-frequency group delay.

2. DESCRIPTION OF THE RECEIVERS TESTED.

Particulars of the receivers tested are shown in Table 1. Two receivers, B and D, were tested immediately after receipt from the manufacturers, but the remaining three had been in use for between one and three years, and were therefore re-aligned before the measurements were made. The alignment procedure adopted in each case was that supplied to service engineers by a trade publication.

TABLE 1

	Receiver A	Receiver B	Receiver C	Receiver D	Receiver E
Size of C.R.T.	12 in.	17 in. (rect.)	14 in. (rect.)	14 in.	15 in.
Number of r.f. amplifying valves	1 (pentode)	1 (cascode)	1 (pentode)	1 (cascode)	1 (pentode)
Type of frequency changer	triode-pentode	triode-pentode	pentode	triode-pentode	triode-pentode
Number of i.f. amplifying valves	3 (pentodes)	3 (pentodes)	2 (pentodes)	2 (pentodes)	2 (pentodes)
Type of detector (vision)	crystal	crystal	diode	crystal	diode
Number of video amplifiers	1 (pentode)	1 (pentode)	1 (pentode)	1 (pentode)	1 (pentode)
Number of amplifying valves in vision chain	6	6	5	5	5
Total number of valves	17	18	13	20	19
Crystal diodes	4	5	1	3	0
Metal rectifiers	1	0	1	1	0
Automatic gain control	None	Mean picture content used for control voltage	None	Gated A.G.C. on black level	None
Type of channel selection	5-channel preset	12-way turret	5-channel preset	12-way turret	5-channel preset
Number of r.f. tuned circuits	3	3	2	3	3
Number of i.f. tuned circuits (vision only)	15	8	4	6	6
Number of rejector circuits	0	6	3	6	5
Vision i.f.	35 Mc/s	35 Mc/s	16·0 Mc/s	34·65 Mc/s	34·5 Mc/s
Sound i.f.	38·5 Mc/s	38·5 Mc/s	19·5 Mc/s	38·15 Mc/s	38·0 Mc/s
Date of manufacture	1951	1954	1952	1954	1953

It will be seen from Table 1 that there is a considerable variation both in the number of valves used, and in the arrangement of the i.f. tuned circuits. Receiver C has a total of only thirteen valves and uses seven circuits in the i.f. amplifier, of which four are bandpass circuits and three are rejectors for the two nearest sound channels. This receiver is somewhat exceptional in the economy of valves and circuits; it is not so sensitive as the other four, and is not intended for use in fringe areas. Receiver A is also unusual in that the fifteen tuned circuits are all used as i.f. bandpass circuits, the resulting selectivity rendering the use of sound rejectors unnecessary.

3. DESCRIPTION OF TESTS.

3.1. Noise Factor.

These measurements were made using a noise diode, care being taken to ensure that the result was not appreciably affected by radiation from the line and frame scanning circuits; where necessary, the scanning valves were removed and the h.t. consumption adjusted by shunt resistors to maintain the normal supply voltages to the stages under test. The results are shown in Table 2.

TABLE 2

Channel No.	Noise Factors in dB				
	Receiver A	Receiver B	Receiver C	Receiver D	Receiver E
1	5·0	6·0	6·0	6·0	6·5
2	5·5	5·5	7·0	5·5	7·0
3	–	–	–	5·5	7·0
4	–	–	–	–	–
5	6·5	6·0	–	–	7·5
8	–	10·0	–	10·0	–

Receivers A and E were each fitted with a sensitivity control in addition to the usual contrast control. The results shown in Table 2 for these two receivers were measured with the control set to maximum sensitivity. In order to measure the effect of the sensitivity control on the noise factor, receiver A was measured on Channel 1 with the control at maximum sensitivity and then at an intermediate position. The results were, respectively, 5·0 dB and 6·5 dB.

Receivers B and D were fitted with automatic gain-control circuits; their noise factors, shown in Table 2, were measured with the control voltage supplied from a battery and held constant at a value corresponding to maximum sensitivity.

For receiver B the control voltage was measured for a range of input levels on Channel 1, the signal being modulated by the waveform of Test Card C. The noise factor was subsequently measured with the control voltage fixed at the value corresponding to each input level; the results are shown in Table 3. The input levels shown are the open-circuit r.m.s. voltages corresponding to peak-white modulation.

TABLE 3

Input level of peak white of picture, μV	Noise Factor in dB for Receiver B	
	High Contrast	Low Contrast
10	6·0	6·0
25	6·0	7·5
100	7·5	11·0
200	10·5	14·0

3.2. Oscillator Frequency Drift.

The local oscillator frequency was measured thirty seconds after the receiver was switched on for the first time on the day of test. The frequency was then measured at regular intervals of time, and the drift is plotted in Fig. 1. A considerable portion of the total drift occurs in the first three minutes, and Table 4 shows the maximum subsequent change of frequency. It will be seen that for Band I the maximum drift which occurs after the first three minutes is between 70 kc/s and 190 kc/s for the different receivers. The drifts which occur after the first three minutes, for the receivers operating in Band III, are 175 kc/s and 300 kc/s.

TABLE 4

Change of Local Oscillator Frequency Subsequent to 3 minutes after Switching On

Receiver	Channel No.	Frequency change in kc/s	
		Band I	Band III
A	1	−125	–
B	1	−190	–
B	5	−155	–
B	8	–	−300
C	3	−70	–
D	3	−70	–
D	8	–	−175
E	1	−85	–
E	5	−115	–

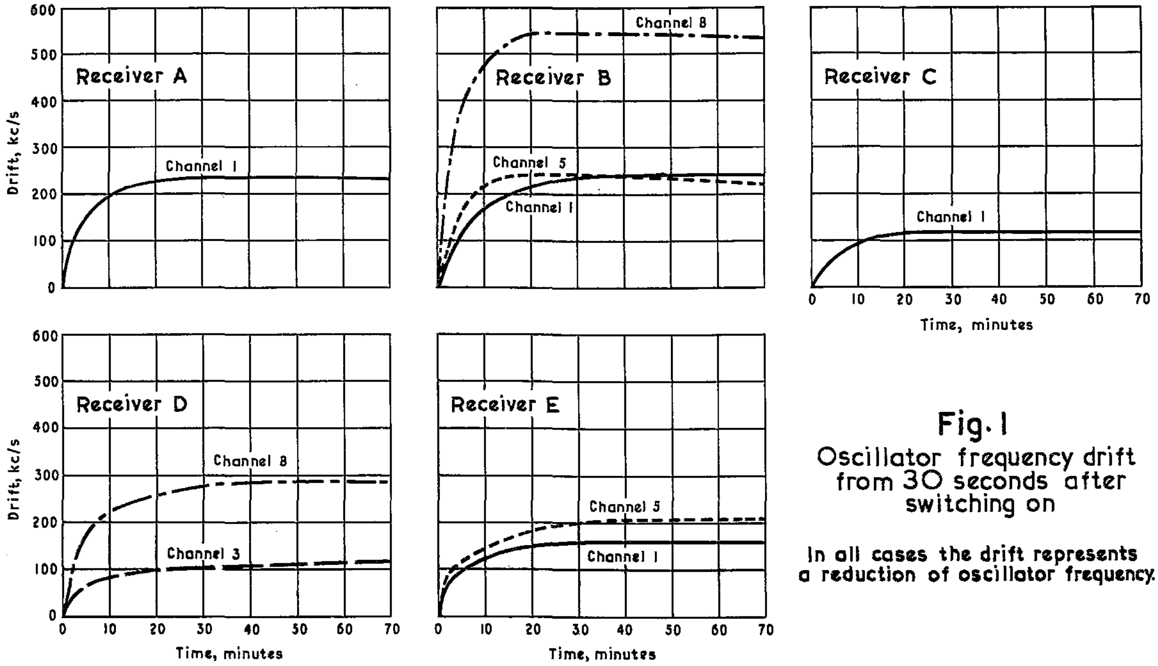

Fig. 1
Oscillator frequency drift from 30 seconds after switching on

In all cases the drift represents a reduction of oscillator frequency.

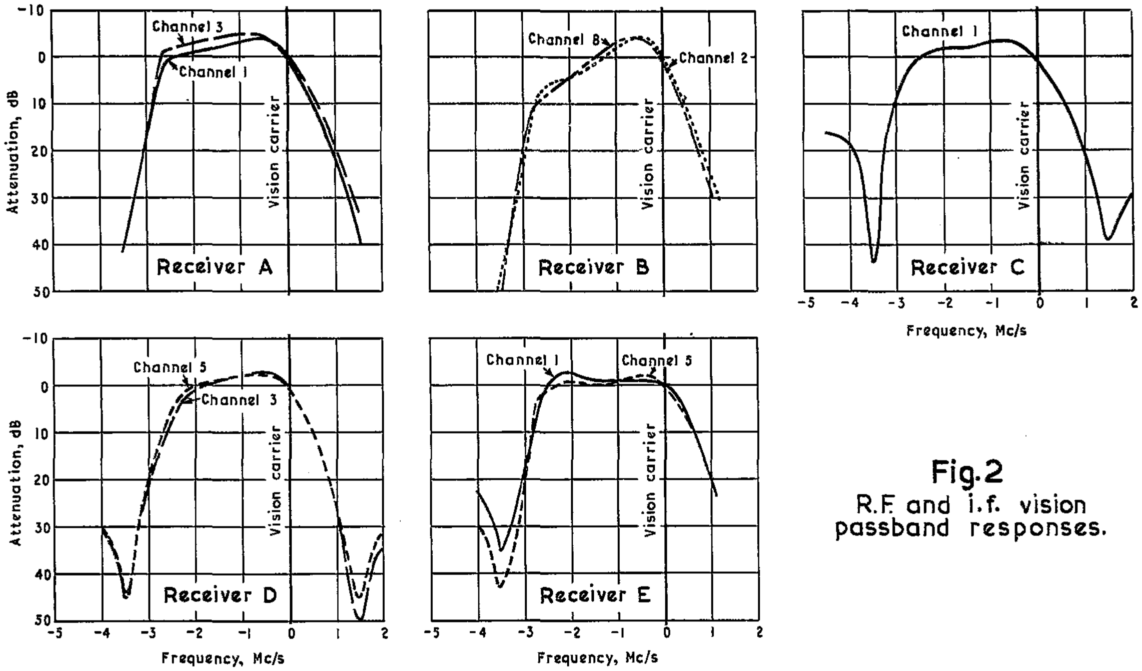

Fig. 2
R.F. and i.f. vision passband responses.

3.3. R.F. and Vision I.F. Passband Response.

These characteristics were measured by tuning a signal generator across the r.f. band and adjusting the output to keep a constant current in the detector diode load; the results are shown in Fig. 2. It is of interest that all the receiver responses are well down at 3·0 Mc/s below the carrier frequency. The receivers have at least 40 dB attenuation at the sound carrier frequency, with one exception, receiver E, which gave 35 dB on Channel 1. It is possible that this was due to i.f. break-through as the sound carrier frequency was 41·5 Mc/s, which is near to the i.f. passband (34·5 to 38 Mc/s); unless the break-through at this frequency was attenuated by more than 40 dB, it would effectively reduce the attenuation of the sound carrier.

The attenuation at the vision carrier frequency relative to that in the passband is less than 6 dB in all cases; this is probably intentional. An increase in the amplitude of the carrier and the adjacent sidebands, besides reducing the distortion inherent in single-sideband reception of deeply modulated signals, can result in a slightly improved signal-to-noise ratio; the resulting loss of high frequency response can, if necessary, be corrected in the video-frequency stages.

3.4. Modulation-frequency Response.

For this measurement the receivers were supplied with a vision carrier, sinusoidally modulated by means of a crystal modulator. The amplitude of the modulation sinewave at the receiver cathode-ray tube was compared with that at the modulator input terminals, the frequency characteristic of the modulator being sufficiently uniform to be neglected. The relative attenuation of each receiver for modulation frequencies between 50 kc/s and 3·0 Mc/s is plotted in Fig. 3.

All the receivers show variations of at least 5·0 dB up to a modulation frequency of 2·5 Mc/s, and at least 12 dB up to a modulation frequency of 3·0 Mc/s.

3.5. Group-delay Characteristics.

These measurements were made with the same arrangement as described in Section 3.4. The relative phase of the modulation sinewaves at the receiver cathode-ray tube and the input to the modulator was measured at regularly spaced frequencies between 50 kc/s and 3·0 Mc/s. The mean group delay was determined by dividing each increment of relative phase angle by the frequency spacing; the results are shown in Fig. 3.

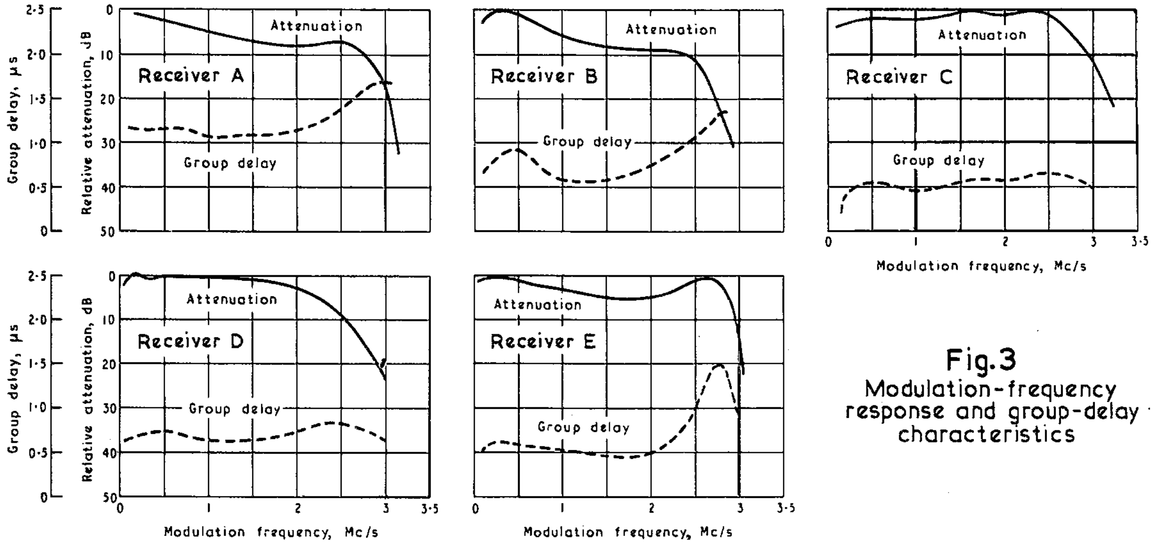

Fig.3
Modulation-frequency response and group-delay characteristics

Receiver D has a group delay which is constant to within ±0·1 μs about a mean value of 0·75 μs. Receiver C has a similar characteristic over most of the frequency range. The other three receivers have a greater variation, receiver E having a group delay varying from 0·45 μs to 1·5 μs.

4. CONCLUSIONS.

The noise factors of the five receivers on maximum sensitivity at frequencies in Band I lie between 5 dB and 7·5 dB. Only two of the receivers could be switched to operate in Band III; the noise factors in these cases were 10 dB.

The oscillator frequency drift from the time of switching on until the frequency is sensibly constant is between 100 kc/s and 250 kc/s in Band I; in the two cases measured in Band III the drifts were 540 kc/s and 290 kc/s. About 30% of the total drift occurs in the first three minutes after switching on.

The modulation-frequency response of all receivers is worse than ±2·5 dB and better than ±5 dB up to a frequency of 2·5 Mc/s; the response at 3 Mc/s is at least 10 dB down in all cases.

In all cases the group delay varies less than ±0·2 μs up to a modulation frequency of 2·0 Mc/s. For two of the five receivers these same limits apply up to a modulation frequency of 3·0 Mc/s; the other three receivers show an increase in group delay of up to 1 μs between 2·0 and 3·0 Mc/s.